Notes on ....

Decline of the riverine trees of the Harvey River delta following the opening of the Dawesville Channel

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Abstract. The three dominant tree species, *Casuarina obesa*, *Eucalyptus rudis* and *Melaleuca rhaphiophylla*, of the riverine vegetation of the Harvey River delta showed a general decline in canopy condition over the four years following the opening of the Dawesville Channel. *M. rhaphiophylla* also showed significant depression in diameter increment for the population closest to the river mouth. The most likely explanation of the tree decline on the Harvey delta is in changes to the salinity regime of the lower Harvey estuary following the opening of the Channel. Further decline of the vegetation is expected.

Key words: vegetation change, salinity, growth rates, canopy decline

Introduction

The Dawesville Channel south of Mandurah was constructed to increase tidal flow within the Peel-Harvey estuary and decrease the occurrence of toxic algal blooms resulting from excess inputs of nutrients from the catchment. Following the opening of the Channel to the sea in April 1994, the tidal amplitude of the Harvey estuary has increased 55% with a significant influx of marine waters and decreased residence time within the estuary (Anon 1998). A study was instigated in late 1994 to monitor the tree health of the lower 4 km of the Harvey River to ascertain if the changes in the salinity regime of the lower Harvey estuary and the greater penetration of salt water up the Harvey River (JAK Lane, CALM, personal communication) were adversely impacting on the riverine vegetation (Fig 1).

Methods

Tree species appear to segregate along the lower Harvey River in response to salinity levels, with the most tolerant species, *Casuarina obesa* Miq (Casuarinaceae, Saltwater Paperbark) restricted to the lower 1.5 km of the river, and the least tolerant species *Eucalyptus rudis* Endl (Myrtaceae, Flooded Gum) appearing as dense stands 2 km above the river mouth and continuing far upstream. *Melaleuca rhaphiophylla* Schauer (Myrtaceae, Swamp Paperbark) is widely distributed along the 4 km length of the lower Harvey.

Thirty individuals of each species were marked at the lower and upper ends of their range in the lower Harvey River. Each individual was marked with a steel tag and girth at breast height over bark (GBHOB) was measured and condition of the tree was scored on a one to five scale (1 < 20% canopy alive, to 5 > 80% canopy alive). The first 30 individuals encountered within 5 m of the river bank were selected for measurement. *Melaleuca rhaphiophylla* is a typical paperbark which sheds bark in long strips every year. Measurement of GBHOB was considered unreliable for this species and basal diameter over bark (BDOB) was measured instead. GBHOB measurements of *C. obesa* and *E. rudis* were undertaken in November 1994 and November 1995, 1996 and 1997. Canopy condition was scored in November 1994, May 1995, and November 1995, 1996 and 1997. Measurements of *M. rhaphiophylla* were undertaken in June 1995, and November 1995, 1996 and 1997.

Influence of year of sampling (seasonal effect) and position of population along river on change in tree diameter were analyzed by a repeat measure two way analysis of variance for each of the three canopy species. To achieve normally distributed data it was necessary to omit from the analysis several atypical individuals that showed increases of eight to ten times the mean values. Analysis of both data sets showed essentially similar results. Differences in tree condition between sampling times and between populations for each species were analyzed separately by Kruskal-Wallis one way analysis of variance since it proved impossible to normalize the data.

Results

The only species that showed no significant decrease in canopy condition during the study period was the upstream population of *Eucalyptus rudis* (Fig 2A). The downstream population showed a small but significant decline in canopy condition. Both *Casuarina obesa* and *Melaleuca rhaphiophylla* showed more dramatic declines in canopy condition over the four years of the study, with the downstream populations being the most affected (Fig 2A). *Melaleuca rhaphiophylla* showed a greater decline (>40% for the population near the river mouth) than was apparent in *Casuarina obesa*.

There was a significant difference in growth increment of upstream (4.0 km from the river mouth) and downstream (0.5 km) populations of *Melaleuca rhaphiophylla* ($F_{1,24} = 19.66$, $P = 0.0002$), with no significant difference between times or the interaction between time and distance. At all time periods during the study, the population near the river mouth recorded no increase in basal diameter (the small decrease recorded probably reflects bark shedding or measurement error; Fig 2B).

Casuarina obesa showed no significant difference in growth increment between the population near the river mouth (0.5 km) and the population 1.5 km upstream. There were significant differences between sampling times ($F_{2,50} = 3.23$, $P = 0.048$), with a non-significant time distance interaction. Negative growth was recorded at both populations during the 1995-96 period (Fig 2C). These negative values probably result from small variation in the location of girth measurements on the stems between years and should be regarded indicating zero growth over the measurement period. Standard errors support this interpretation.

Eucalyptus rudis, which occurred further up the river system than the other two species, generally had larger growth increments (Fig 2D). There was both a significant difference between the downstream population (2.0 km from river mouth) and the upstream population (4.0 km) ($F_{1,26} = 8.60$, $P = 0.007$) and sampling periods ($F_{2,52} = 10.44$, $P < 0.0002$). There was no significant interaction effect.

Figure 1. Harvey River delta from the southern end of the Harvey estuary looking south. Photograph G Pearson, CALM.

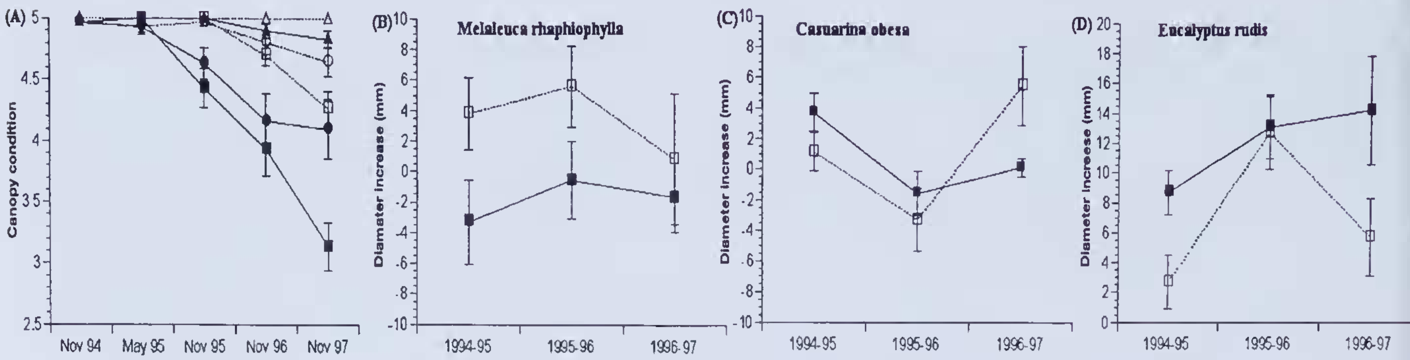

Figure 2. A: Changes in canopy condition over time. Canopy condition scored on five point scale (1 < 20% canopy alive, to 5 > 80% canopy alive). Triangles – *Eucalyptus rudis*, Circles – *Casuarina obesa*, Squares – *Melaleuca rhaphiophylla*. Dotted line and open symbols indicate upstream populations, solid lines and solid symbols downstream populations. B: Growth increment over three measuring periods for *Melaleuca rhaphiophylla*. Solid symbols indicate downstream population (0.5 km from river mouth), open symbols indicate upstream population (4.0 km). C: Growth increment over three measuring periods for *Casuarina obesa*. Solid symbols indicate downstream population (0.5 km from river mouth), open symbols indicate upstream population (1.5 km). D: Growth increment over three measuring periods for *Eucalyptus rudis*. Solid symbols indicate downstream population (2.0 km from river mouth), open symbols indicate upstream population (4.0 km).

Discussion

There has been a significant decline in the canopy condition of five of the six populations of the dominant riverine tree species monitored since the opening of the Dawesville Channel (Fig 2A). The decline has not been uniform across the species studied with *Melaleuca rhaphiophylla* showing a greater degree of decline than the other two species. While no direct causal relationship between the opening of the Channel and the decline of the trees has been demonstrated, the period of decline exactly correlates with the opening of Harvey Estuary to more direct marine influences, as does the death of fringing vegetation along much of the western shore of the Harvey Estuary (JAK Lane, CALM, personal communication). The pattern of canopy decline in *Eucalyptus rudis* was not consistent with a leafminer outbreak which have been reported from elsewhere in south west Western Australia (Abbott *et al.* 1999).

Melaleuca rhaphiophylla showed clear a depression in growth rate at the river mouth population compared with the upstream population. No increase in diameter was recorded for the river mouth population during any of the three growth periods (Fig 2B). Very low or zero growth rates were also generally recorded in both populations of *Casuarina obesa* which occupies the lower 2 km of river. The low growth rates, except for the upstream population at the last sampling period, are consistent with populations under stress (Fig 2C).

Eucalyptus rudis that occurs above 2 km from the mouth generally showed higher growth rates than the other two species. In contrast to the pattern seen in the other two species the downstream population grew significantly faster, although as noted above this population showed greater degree of canopy decline. These results are somewhat unexpected as glasshouse and field experiments of seedlings planted into saline soils indicate that *Eucalyptus rudis* is a salt sensitive species (Pepper & Craig 1986; van der Moezel *et al.* 1991). The hydrology of the root zone of *Eucalyptus rudis* along the Harvey River is likely to be complex as the intruding salt wedge lies below a freshwater lens whose characteristics change throughout the year (JAK Lane, CALM, personal communication).

Eucalyptus rudis also showed significant differences in the growth rates between time periods. This was also true for *Casuarina obesa* and, although there was no significant difference between times for *Melaleuca rhaphiophylla*, the trend was consistent with the pattern shown in *Eucalyptus rudis* (Fig 2B,C). It is interesting to note that the pattern in growth over time for *Casuarina obesa* is opposite to that recorded for the other two species.

These data are consistent with a stress-induced response of the canopy to an increase in the penetration of salt water up the lower Harvey River as a result of an increased marine influence in the Harvey Estuary. Significant canopy decline was noted for all populations except for the *E. rudis* population 4 km from the river mouth, with the downstream populations being the most severely affected. Surprisingly there was a large decline in the canopy condition of *M. rhaphiophylla* even as far as 4 km above the river mouth. Growth rates were low or zero for the *M. rhaphiophylla* population near the river mouth and for both populations of *C. obesa* found in the lower 2 km of the river. While the trends in the data are consistent with general tree decline in the lower Harvey there are substantial differences in the responses of individual species especially *E. rudis* which was recorded only above 2.0 km of the river mouth. The long term rainfall average for Pinjarra (20 km north west of the study area) is 951 mm, rainfall over the study period was below average and not correlated with the observed patterns (1995, 807 mm; 1996, 848mm; 1997 676 mm).

There is no indication of a decrease in the rate of decline of the canopy condition and further deterioration should be expected. It is likely that over the next decade the composition of the canopy species along the lower reaches of the Harvey River will change substantially.

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